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Electric Circuits

Unit: 6 | Lecture: 27

Capacitors and Inductors:

Series and Parallel Capacitors

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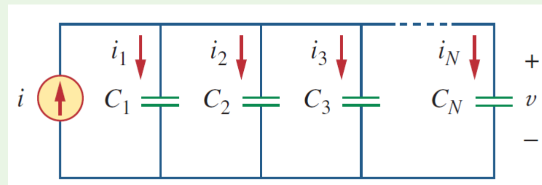
Capacitors and Inductors

6.3 Series and Parallel Capacitors

To obtain the equivalent capacitor C_{eq} of N capacitors in parallel,

Note that the capacitors have the same voltage v across them.



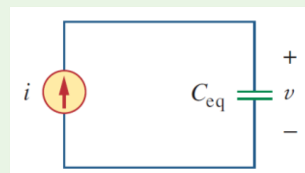
Parallel-connected N capacitors

Applying KCL

$$i = i_1 + i_2 + i_3 + \ldots\ldots + i_N$$

$$i = C_1 \frac{dv}{dt} + C_2 \frac{dv}{dt} + C_3 \frac{dv}{dt} + \ldots\ldots + C_N \frac{dv}{dt} = C_{eq} \frac{dv}{dt}$$

$$C_{eq} = C_1 + C_2 + C_3 + \cdots + C_N$$



equivalent circuit

The equivalent capacitance of N parallel-connected capacitors is the sum of the individual capacitances.

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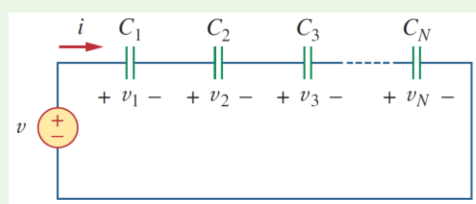
6.3 Series and Parallel Capacitors

To obtain the equivalent capacitor C_{eq} of N capacitors in series,

Note that the same current i flows through the capacitors.



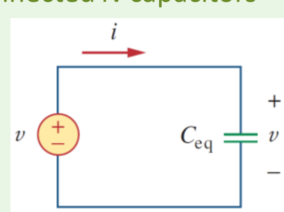
Series-connected N capacitors

Applying KVL

$$v = v_1 + v_2 + v_3 + \ldots\ldots + v_N$$

$$\because v_k = \frac{1}{C_k} \int_{t_o}^{t} i(\tau)\, d\tau + v_k(t_o)$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_N}$$



equivalent circuit

The equivalent capacitance of series capacitors is the reciprocal of the sum of the reciprocals of the individual capacitances.

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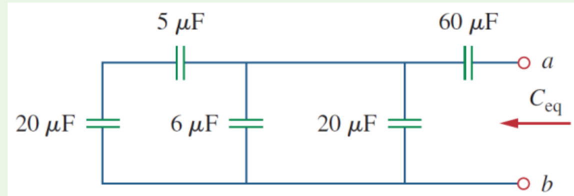
Example 6.6

Find the equivalent capacitance seen between terminals *a* and *b*



The 20 μF and 5 μF capacitors are in series;

$$\frac{20 \times 5}{20 + 5} = 4\ \mu\text{F}$$

This 4 μF capacitor is in parallel with the 6 μF and 20 μF capacitors;

$$4 + 6 + 20 = 30\ \mu\text{F}$$

This 30 μF capacitor is in series with the 60 μF capacitor;

$$C_{eq} = \frac{30 \times 60}{30 + 60} = 20\ \mu\text{F}$$

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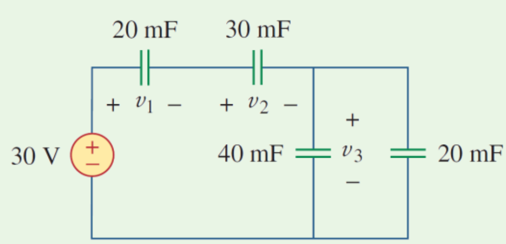
Example 6.7 (1)

Find the voltage across each capacitor.

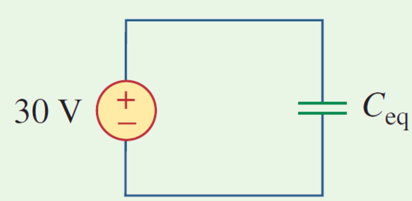


The two capacitors 40 and 20 mF are in parallel

40 + 20 = 60 mF

This 60-mF capacitor is in series with the 20-mF and 30-mF capacitors.

$$C_{eq} = \frac{1}{\frac{1}{60} + \frac{1}{30} + \frac{1}{20}}\ \text{mF} = 10\ \text{mF}$$



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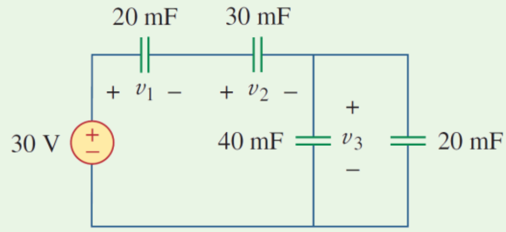
Example 6.7 (2)



The total charge is

$$q = C_{eq}v = 10 \times 10^{-3} \times 30 = 0.3 \text{ C}$$

This is the charge on the 20-mF and 30-mF capacitors, because they are in series with the 30-V source.

$$v_1 = \frac{q}{C_1} = \frac{0.3}{20 \times 10^{-3}} = 15 \text{ V}$$

$$v_2 = \frac{q}{C_2} = \frac{0.3}{30 \times 10^{-3}} = 10 \text{ V}$$

use KVL to determine

$$v_3 = 30 - v_1 - v_2 = 5 \text{ V}$$

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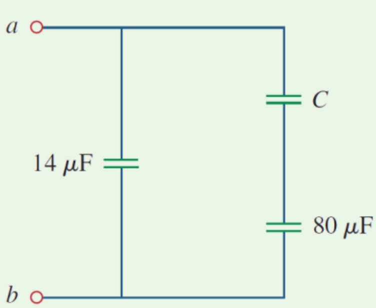
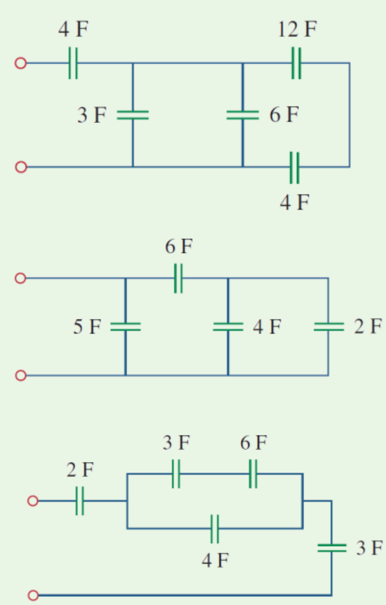
Problems to Solve by yourself

(1) Series-connected 20-pF and 60-pF capacitors are placed in parallel with series-connected 30-pF and 70-pF capacitors. Determine the equivalent capacitance.

(2) The equivalent capacitance at terminals *a-b* in the circuit is 30 μF. Calculate the value of *C*.



(3) Determine the equivalent capacitance for each of the circuits.



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